D. Monitoring MNM Miners Exposures to DPM

General comments on monitoring MNM miners' exposures to DPM:

a) One commenter noted that the MSHA Total Carbon (TC) exposure standards for MNM mines are based on both Elemental Carbon (EC) and Organic Carbon (OC), unlike the exposure metric used in the DEMS studies, which were based on EC. This commenter noted the complexities in coal mines, where EC and OC are present in coal dust, and asked MSHA to continue to be mindful of the difficulties coal operators face in accurately measuring the diesel exhaust exposure for their workforce.

b) A second commenter stated that NIOSH Method 5040 provides acceptable ways of sampling and analyzing diesel exhaust, but cannot measure DPM in short term analysis. This commenter stated that real-time monitors are gaining more attention from NIOSH, and are more accurate at detecting the diesel exhaust than NIOSH 5040 methods. This commenter stated that environmental changes in humidity and temperature affect the sensors in currently available real-time monitors, and cited literature stating that these sensors can give accurate readings for the first two hours, but then start to falter. [Comment].

c) A third commenter, from a non-U.S. mining company, described monthly personal exposure monitoring using NIOSH method 5040, based on elemental carbon, in a coal mine. The commenter stated that all cases where exposure exceeds 0.03 mg/m^3 are investigated to identify and address potential sources of exposure and exposure situations. This same commenter noted that, in a (non-U.S.) MNM mine using NIOSH 5040 EC, the mean exposure of all similar exposure groups (SEGs) is less than 0.05 mg/m^3 EC and just two SEGs exceed 0.04 mg/m^3. Using the 95% UCL of the mean exposure, all SEGs have exposure less than 0.08 mg/m^3 and 65% have exposure less than 0.05 mg/m^3. The commenter included a data table [Commenter Figure 4, p. 11].

d) A fourth commenter (also non-U.S.) discussed the variability in TC/EC ratio in different mines in the context of ventilation planning and regulatory limits. This commenter stated that, for South African underground platinum mines, a median TC/EC ratio of 1.8 with a range of 1.2 to 5.8 was observed. For South African coal mines, a median TC/EC ratio of 1.44 with a range of 1.25 to 2.13 was observed. While it is common practice in the USA to use the ratio of TC/EC for metal mines to be 1.3, the ratio found in local platinum mines is 2.2 and for coal mines, the ratio was 1.53 which is lower than Australian studies, i.e., 1.96 (although this Australian coal mine DPM TC/EC ratio of 1.96 did not hold true based on the latest statistics). This commenter also submitted two studies discussing DPM exposure monitoring. [Comment], [Belle 2008], [Gillies 2014].

e) This fourth commenter requested that MSHA address the following:

- Can the rulemakers share or provide the latest USA DPM statistics on TC/EC ratios? Also, provide reasons for any deviation from the historic TC/EC ratio of 1.3 if such is the case?
- While, the current US studies have developed appropriate error factors (currently 1.14 for TC and 1.2 for EC) for compliance determination, with an historic TC/EC ratio of 1.3, a table of error factors for different practical TC/EC ratios as obtained from the latest US DPM data would be beneficial.
- Why do the coal mines in the USA not carry out personal DPM exposure measurements? Can the rulemakers provide at least the justifications for not carrying out personal DPM exposures in coal mines? How would one establish DPM dose-response curves in future?
- Can the latest rule also provide the technical information on deposition area standard used in the calculation of DPM concentration as in NOSH 5040 method, i.e., is the deposition area 8.55 cm2 or 8.40 cm2 or 8.04 cm2? This would assist in international harmonization of comparing the DPM results as well as establishing ventilation dilution factors in current and new mine ventilation system designs globally.
- Are MSHA/NIOSH pursuing the tapered element oscillating microbalance (TEOM) technology for use in personal DPM measurement (similar to the PDM3700 continuous personal dust monitor (CPDM) used for respirable coal dust exposure measurement)? It is important that the rulemakers maintains a regular interest on the CPDM in order to ensure that the manufacturer/supplier provides the necessary quality and continued user support for improvement opportunities with a shared aim of worker protection.
- This commenter also submitted two studies discussing DPM monitoring practices and variability in the TC/EC ratio.

f) A fifth commenter submitted four studies/manuscripts discussing DPM exposure monitoring. [Czerwinski 2007], [Noll and Birch manuscript], [Noll, Mischler et al manuscript], [Vlachos 2014].

24. MSHA requests information on alternative surrogates, other than TC, to estimate a miner's DPM exposure. What is the surrogate's limit of detection and what are potential interferences in a mine environment?

a) Two commenters noted that TC cannot be measured in real-time, which delays the response time to correct any elevated concentrations.

b) These two commenters mentioned using carbon monoxide (CO) as a surrogate, with one stating that CO may be a viable alternative, and the other stating that MSHA should consider other surrogates, including carbon monoxide (CO), with a careful analysis of how other activities in the mine could affect levels of potential surrogates, and another.

c) One of these commenters stated that organic byproducts, such as shale oil, can interfere with the detection of TC. This commenter noted that MSHA has sought alternatives for TC for over 15 years. This commenter noted that the problem with adopting a new surrogate, in part, is that we will have to compare the TC data with the new data, which will make it difficult to measure DPM levels over time and progress in reducing DPM.

d) A third commenter did not have a recommended alternative to the current combination of total carbon (TC) and elemental carbon (EC). This commenter noted problems with sampling artifacts and interferences for the organic fraction of TC, and sampling techniques to reduce interferences (e.g., do not sample near welding or cigarette smoking). This commenter noted problems in establishing a consistent TC/EC ratio to allow use of EC as a standalone. This commenter stated that the relationship between the EC and OC or TC depends on engine type, engine operating conditions, fuel type, and exhaust after-treatment type, and noted that future control mitigation strategies might alter DPM composition, such that EC would no longer be representative of DPM exposure. This commenter recommended:
   - Introducing an additional exposure metric, such as particle number concentration or surface area concentration, for example using commercially available real-time monitors equipped with size-selective samplers;
   - Using size-selective personal EC sampling to monitor coal miner's exposure to DPM, since the high organic content of coal dust makes TC an ineffective surrogate;
   - Improving procedures for certification of diesel engines and verification of exhaust after-treatment technologies, including detection of secondary emissions of toxic substances, and addition of particle number and surface area concentrations, for example in recent Swiss regulations (FOEN 2016). This commenter cited current requirements under 30 CFR. [Comment].

25. What are the advantages, disadvantages, and relative costs for using the alternative surrogate to determine a MNM miner's exposure to DPM?

a) One commenter stated that MSHA should consider other surrogates, including CO, focusing on the technical challenges and benefits of each method.

b) A second commenter discussed the ways in which EC sampling and analysis is simpler than TC sampling, while noting its limitations. This commenter noted that metrics that are more closely tied to the health effects of DPM should be used - particle number, surface area, or size distribution may provide better monitoring, hazard assessment, and risk management related to the exposure to diesel aerosols emitted from contemporary engines and control technologies, particularly those with high mass-specific surface areas. The commenter noted that these types of monitoring strategies still need further development and validation. This commenter also submitted a study discussing an exposure

monitoring method for diesel particulate, and cited other studies. [Comment], [Birch 1996].

26. MSHA requests information on advances in sampling and analytical technology and other methods for measuring a MNM miner's DPM exposure that may allow for a reduced exposure limit.

a) Two commenters expressed concern about the reliability of continuous monitoring systems for incomplete combustion gases in the mine environment. This commenter cited an evaluation of real-time monitoring systems published in the *Journal of Occupational and Environmental Hygiene* which found the monitored results could deviate up to 20% from the NIOSH Method 5040 results. [Comment], [Comment].

b) One of these commenters stated that another possible tool is diesel particulate monitors, which can monitor elemental carbon in real-time. The monitors employ a particle capture and light transmission to discern elemental carbon values, which in turn correlate with NIOSH 5040 test results. The commenter stated that while these monitors assist in evaluating adjustments to ventilation, they do not measure TC levels. [Comment].

c) A third commenter described an alternative method, a proven maintenance free continuous DPM sampler based on acoustic and laser technology, currently used for monitoring around cities and forest fires, that has been tested in an underground mine. This commenter suggested further development of the instrument be undertaken for a smaller, more robust, and more portable unit to be used by mine supervisors and miners in both coal and MNM mines. This commenter also submitted a study manuscript on technology. [Comment], [Arnott manuscript].

d) A fourth commenter described a near real-time EC monitor developed by NIOSH. Real-time, on-site measurements with this monitor provide timely information that can be used as an engineering tool to identify factors contributing to overexposures, characterize exposure patterns (e.g., high transient exposures), and allow for quick deployment of engineering controls. The monitor measures the EC concentration via laser extinction. [Comment].

e) This commenter also stated that, if EC is used in place of currently used TC and EC as a DPM surrogate, the NIOSH Analytical Method 5040 would be adequate to assess DPM concentrations at compliance levels (and much lower) in metal/nonmetal (MNM) and coal underground mines. This commenter discussed ways to further decrease the limit of detection, and also cautioned that the SKC DPM cassette performance is altered during prolonged sampling in dusty environments, as the size selector loads with respirable dust.